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GLOBAL MATCH: HELPING SMALL WINERIES GAIN ACCESS TO MARKETS WORLDWIDE

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GLOBAL MATCH:
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Susan CHOLETTE

Abstract

As the United States is predicted to become the world's largest wine consuming nation by 2008 with consumers purchasing across all price segments, one might assume that Californian wineries should thrive in this market. However, regulations and consolidation effects often prevent small wineries from being able to reach the U.S. consumer and they face similar problems with exporting. These wineries must seek specialty distributors that represent lesser-known brands, usually by attending trade shows at great expense. In turn, specialty distributors face the daunting challenge of finding wineries that best satisfy their portfolios' needs.

Given this problematic situation, can one provide assistance to these parties in their quest for finding appropriate partners? While this question no doubt has many positive answers, the approach we have chosen to explore is to develop a web-based matching program. We ask wineries and distributors to submit their respective attributes and their needs via a web questionnaire. Operations research methodology is then used to algorithmically determine the most promising partnerships, subject to mutual fit and based on constraints of supply, demand and avoidance of conflicting matches.

We summarize the results obtained from the initial iteration of the program, a pre-qualification service created for the World Wine Market, a San Francisco trade show in 2004. We provide some of the participant feedback, including testimonials from parties that were successfully matched through the program. We also analyze the results to determine why the program did not recommend a greater number of matches and used this information and other feedback to assist in the development of the next program iteration

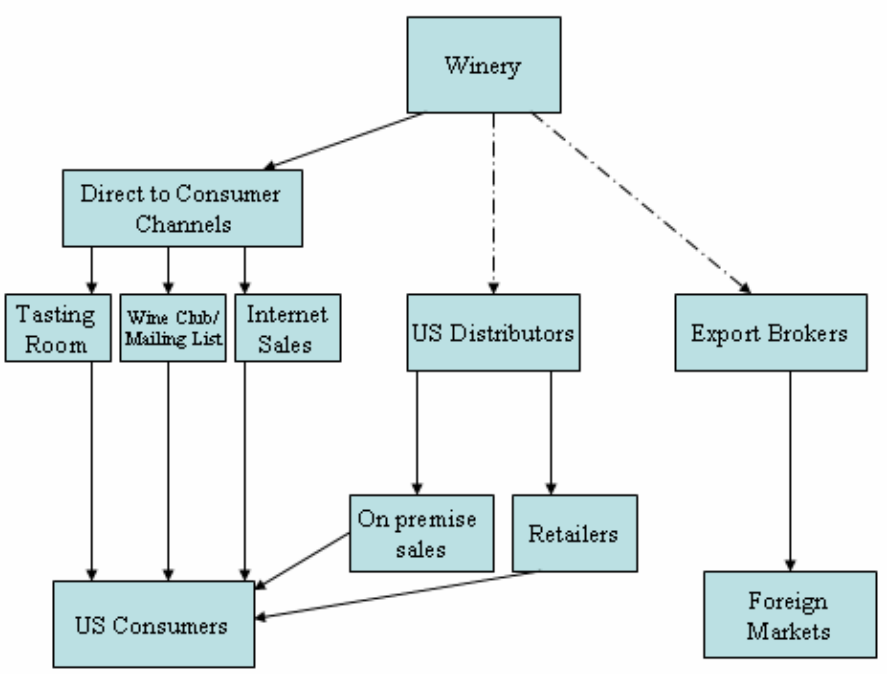
While the conceptual contribution of our research is in providing the first documented application of "assignment problems" to model the optimal placement of wines into the distribution tier, this paper focuses instead on the potential practitioner contributions to the wine industry. A functional web based matching program could provide many small wineries with a means to expand their representation into additional markets domestically and internationally. Even if only a small fraction of the recommended matches take place, the business return from participation has enormous potential. We discuss the current improvements, which being funded through a Business and International Education Grant from the U.S. Department of Education. We conclude with ideas for future research, including extending this program to a broader range of participants.

1. Introduction: Motivation for Research

At first glance of the wine business headlines, one might expect that Californian wineries would be poised for certain success. The U.S. is projected to become the largest wine consumer by 2008, buying 25% of global wine production (Bloomberg, 2005). American consumers purchase wines across all price segments and in recent years have been purchasing more expensive wines. The U.S. Supreme Court has struck down state laws that enabled discrimination against out-of-state wineries' direct shipments, such as New York's prior ban against direct shipments from California. Lastly, as if a larger, richer and more open domestic market were not sufficient, Californian exports have also increased in recent years.

However, a deeper look beyond the headlines paints a more troubling picture for the typical Californian winery. While the state has over 1500 wineries, the big three, Constellation Brands, E. & J. Gallo and the Wine Group, sold over 170 million cases of wine in 2005, roughly 60% of total U.S. sales (Gray, 2006). The larger producers have a natural advantage in working with wholesalers who themselves have consolidated to the point that the largest 20 control over 70% of the distribution tier (National Wine & Spirits, 2004). Figure 1 depicts the paths by which a winery can reach domestic and international markets. As can be seen, distribution is a crucial step to reach the U.S. retail market, and it is difficult to bypass, given that the repeal of prohibition mandated alcohol sold in the U.S. must pass through a three-tiered distribution system, with every state having its own regulations. Not surprisingly, a survey by the Wine Institute (2003) shows that 75% of wineries felt that the increasing consolidation of distributors has adversely affected their ability to find representation. While small-scale and specialty distributors exist, it is hard for the wineries to find their contact information, much less commence a business relationship.

Figure 1 The Demand Chain: How Wineries Reach Their Markets



Source: Author's contribution.

Another problem facing Californian producers is that they can no longer rely on a domestic market advantage. Market size, consumer affluence and consumer willingness to try wine of different styles and origins all make the U.S. an attractive venue for producers worldwide. Export powerhouses Australia and Chile have both determined that the U.S. is their most profitable market (Heeger, 2004). The ratio of U.S. exports to imports has been in steady decline since the mid 1990's (Cholette, 2004). Within this decade, Californian wineries' share of

the U.S. market, once 75%, has fallen to 66% (Wasserman, 2006). While many imports have been lower priced New World wines, industry experts predict that these new exporters, having established a loyal consumer base, will be able to move into higher priced wines (Quackenbush, 2006).

Direct-to-consumer shipping has been cast as the salvation for the family winery. However, the recent relaxation of restrictions is misunderstood by the public in general and even by some experts. The 2005 Supreme Court ruling prohibits only discriminatory interstate shipping, but does nothing to open states closed to shipping. States can choose to remain or become closed to all direct shipping. Open states can also force wineries to apply for shipping permits, requiring time, money and paperwork. Additionally, while the direct-to-consumer channel is growing, it accounts for only 10% of total wine sales volume. Even a direct shipping proponent, Katie Schumacher, the CEO of a company that provides logistical support for direct shipping, has predicted it will likely remain a channel of limited growth (Cholette, 2004). Lastly, the high cost for transport and the inability for direct shipping to capture the "impulse buy," which is responsible for many supermarket wine sales, means that that this channel has reduced potential, especially for mid-priced producers. Unless wineries already have a large mailing list of clients or a realistic business plan to generate one, they cannot expect to rely on direct shipping as their sole sales outlet.

The export market is likewise daunting for small producers, as they lack the economies of scale necessary to market their wine to buyers in foreign markets. While 17% of Californian production is exported (Wasserman, 2006), much of this trade is from the larger brands. France is listed as one of the top 10 export markets for U.S. wines. But a cursory Paris-based survey of several supermarkets, Auchan, Atac, Carrefour, and Intermarché, as well as the dominant national chain of wine stores, "Nicolas", finds Californian wine brands only from giants E. & J. Gallo and Constellation. These supermarkets, which account for the majority of French wine sales, stock wines from small producers from other countries, yet the small Californian wineries have no representation on these shelves. U.S. governmental support for exporting wine is minimal, especially when compared with Australian and European efforts to support their own wine sectors. Regional wine organizations such as the Paso Robles Vintners and advocacy groups such as the Wine Institute help to promote Californian wine as a category, but still leave wineries with the need to find potential partners themselves, preferably in a manner that does not involve the time and expense of international travel.

Thus even in the land of opportunity, Californian wineries that are neither part of a large corporation nor small enough to sell direct to niche markets are facing difficult times, and many are in danger of going out of business or in being bought out. The chance for many of these vintners to continue to survive as independent entities is to partner with specialty distributors and export brokers seeking lesser known brands for wine shops, restaurants and other clients looking for more variety. To find these potential partners, wineries often have to visit distributors' offices or attend tradeshows, which travel costs often proscribe.

1.1. Creating a Matching Program

Given all these difficulties, the fundamental question to investigate is how to help wineries find these partners. The aforementioned Wine Institute (2003) survey demonstrates that this is a valid question to attempt to answer. Recent academic and industry efforts have focused more on consumer segmentation research and category promotional campaigns, such as the Wine Institute's (2006) campaign to promote Californian wine through leveraging worldwide consumers' positive associations with the state. We introduce a different approach: creating a web-based matching program that can provide wineries pre-qualified contacts with interested buyers, based on mutual needs and interests. A survey of current research efforts as well as conversations with winemakers and distributors shows that no such current program exists. The Marlborough Regional Development Trust in New Zealand is attempting to set up an internet-based distribution system to encourage producers and consumers to transact directly (Stuff, 2005). Baritaux et al (2005) measure the efficacy of wine brokers, who serve as matchmakers that enable buyers and sellers of *bulk* wine to meet and transact. However, no

one else has yet created a matching program for wineries and distributors nor even written about the feasibility and approach for doing so.

Matching wineries to distributors is a complicated task, as wines are far from homogenous commodities. As would be implied by their name, specialty distributors that seek to expand their portfolio of wine brands often have very exacting needs, since they need to be able to compete with the large conglomerates on factors beyond being the lowest cost provider. For instance, they may seek to find new Merlots, but only within the USD 10 to USD 14 price range. Or they may be less concerned with varietals and price points and instead focus on offering a palette of wines from a specific appellation. Napa or Sonoma wines tend to be more sought after than those from the Central Valley, but wines from previously less known regions, such as the Santa Ynez area recently featured in the popular American movie "Sideways" have gained many distributors' interests as being novel. In Cutler (2005), distributors express frustration at being able to find wineries who understand their business needs and the difficulties in representing a brand in a market with so much variety.

Wineries have their own goals. Producers often do not have the volume to support nationwide sales of their product, and they may target a region that is the best fit for their product and marketing goals, rather than scattering bottles haphazardly across the country. They may prefer to reach markets with specific demographics, such as Florida and Arizona, with their greater concentration of retirees. Specialty distributors usually have limited domains, with licenses for at most a few states. Lastly, the volume of the transaction must be considered. A distributor who requests a 500 case allocation of a winery's 2,000 cases of Paso Robles syrah leaves that winery in need of a market for the remaining 1,500 cases.

1.1.1. The Starting Point: 2004 World Wine Market Trade Show

The prototype of Global Match was created for the World Wine Market held in San Francisco in May 2004. Although other similar events such as Rhone Rangers cater more to the end consumer, the main purpose of this trade show was in providing wineries and distributors with a venue to meet. The goal of our matching program was not to create definitive pairings but rather to pre-qualify potential partnerships, allowing for arranging meetings in advance, based on compatibility of mutual needs and goals. Questionnaires for both wineries and distributors were created that collected participants' attributes and needs, as shown in Figure 2.

Figure 2 Attributes and Preferences Used for Matching

	Winery	Distributor/Broker
Attributes	Winery Location Wines (up to 6 specified) by: Appellation (if different than organization's location) Varietal/Blend Price-Point Cases Available	States or countries represented
Preferences	Desired markets by state or country (up to 8) ranked in order of preference	Wines (up to 6 separate inquiries allowed) specifying: Varietal/Blend Region Price Range Cases Desired

Source: Author's contribution.

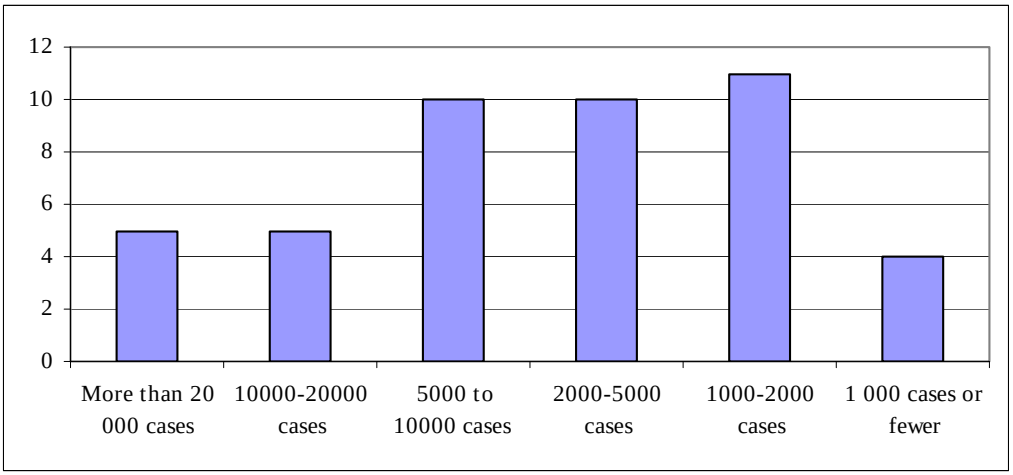
Both wineries and distributors have characteristic attributes as well as preferences regarding the attributes they seek in potential partners

A subset of the invitees returned usable forms, including 45 wineries from California and Oregon and 15 distributors and brokers. Over 200 distinct products were entered by the wineries, and distributors provided a total of 56 inquiries. None of the participating wineries produced more than 100,000 cases a year nor were owned by larger corporate entities. While some were micro wineries, producing less than 1,000 cases/year, the average winery size was

6,000 cases/year. As can be seen from Figure 3, most fall into the small to mid-sized range that are often considered too small to attract the attention of the large distributors yet too big to rely on selling only through direct channels.

The following numbers show why some automated assistance with matching might be useful. Were each distributor to evaluate all the products, over 3,000 distinct combinations would be possible. A further complication is that distributors may consider wines in multiple price ranges based on certain qualifications. A typical example would be a distributor's interest in chardonnays of different characteristics. They might be willing to pay USD 10 to USD 25 for a Sonoma chardonnay but no more than USD 15 for a chardonnay lacking a Sonoma appellation. Thus the additional dimensionality of the distributor's specific inquiry must be considered, raising the number of combinations possible to nearly 13,000 for this small group of participants. As many of the wineries' products will not fit a particular distributor's needs, the ability of the participants to find potential matches during a brief trade show without some pre-qualification is limited. The benefit of using automated matching algorithms to pre-select potential pairings has obvious appeal.

Figure 3 Number of Participating Wineries by Annual Case Production



Source: Data from original matching program, May 2004.

Likewise, the wineries' own goals for distribution must be taken into account. As mentioned previously, they may wish to selectively target markets, and thus some distributors will be more attractive than others, given their coverage. While these markets could include overseas countries, the initial program focused on U.S. distribution, with a winery allowed to rank up to eight states. Participant input shows that some wineries sought only a few states, such as one small winery's request for Californian distribution, while others had wider searches. The majority took the latter approach, and the average number of markets requested was seven states. In order to quantify the relative attractiveness of a distributor for a winery, we devised a weighting scheme based upon the rank and number of states a winery requested, as per Figure 4.

Figure 4 Weighting Scheme for Wineries' Preferred Markets

# markets	weight 1	weight 2	weight 3	weight 4	weight 5	weight 6	weight 7	weight 8	sum
1	1								1.0
2	0.55	0.45							1.0
3	0.383	0.333	0.284						1.0
4	0.325	0.275	0.225	0.175					1.0
5	0.3	0.25	0.2	0.15	0.1				1.0
6	0.29	0.24	0.19	0.14	0.09	0.05			1.0
7	0.26	0.22	0.18	0.14	0.1	0.06	0.04		1.0
8	0.23	0.2	0.17	0.14	0.11	0.08	0.05	0.02	1.0

Source: Author's contribution.

Weights sum to one to give wineries equal representation. This normalization could be interpreted as letting wineries spread their vote for what markets they wish to access. The more a winery desired states covered by that distributor, the more attractive that distributor will be as their potential partner. Thus a distributor's attractiveness to a winery can range from zero (no states of interest covered) to one. Figure 5 shows an example of how a sample distributor meets two different wineries' geographic preferences.

Figure 5 Example of How a Distributor Would by Rated by Two Wineries

1. Given the following:
Distributor D2 can distribute in NY, NJ and PA
Winery WA seeks up to 4 states: 1st place-NY, 2nd-NJ, 3rd-WA and 4th-VA
Winery WB seeks up to 7 states: 1st place-CA, 2nd-NV, 3rd-NY, 4th-NJ, 5th-FL, 6th-CO and 7th-MA

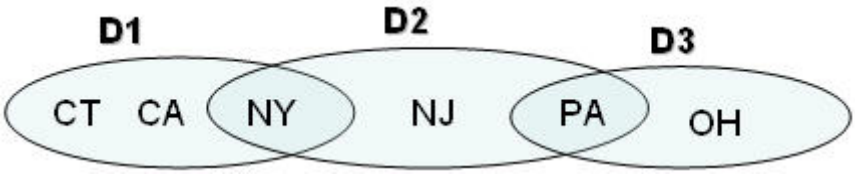
2. Referring to Figure 4 for Row 4 (for WA) and Row 7 (for WB)
D2 has WA's 1st and 2nd choice markets with cardinal preferences of .325 and .275
- The geographical attractiveness of D2 for WA is calculated as .325 +.275= **0.60**

D2 has WB's 3rd and 4th choice markets, with cardinal preferences of .18 and .14
- The geographical attractiveness of D2 for WB is calculated as .18 +.14 = **0.32**

D2 better reflects the geographical preferences of WA than of WB, and, all other things equal, the matching process would favor allocating wine to D2 from WA rather than from WB.
Source: Author's contribution.

An additional condition needs to be considered in evaluating compatibility: avoiding creating domain overlap. Part of the value provided by distributors to wineries is promoting and raising awareness of a wine brand with specific retailers and on-premise accounts in their territory. Distributors often expect to retain sole rights to represent that wine brand within a specific state, if not their entire territory. Distributors whose domains overlap tend to view each other as rivals, and they may prefer that the winery does not deal with a rival even if the brand is targeted for distribution in a state that they themselves are not licensed for. These expectations for a monopoly on distribution are often enforced by law: in certain states "Primary Source" rules allow a distributor to insist on sole rights of representation and even prevent a client winery from leaving to form a new relationship with another distributor in that state. Domain overlap is illustrated by Figure 6 as follows.

Figure 6 Example of Overlapping Distributor Domains



Source: Author's contribution.

Distributors D1 and D2 overlap in their representation of New York (NY), and D2 and D3 overlap in their representation of Pennsylvania (PA). If a winery partners with D2, it should avoid partnering with either D1 or D3. But as D1 and D3 have no common markets, a winery could partner with both distributors simultaneously. Additionally, wineries with existing distributor relationships should not be matched to those where domains overlap. Given the example above, if a winery already has distribution in California, it should not be matched with D1.

With all of these conditions, the ability of the participants to qualify potential matches within the timeframe of even a small tradeshow's duration is limited. Other tradeshows are often much larger; more than 2,000 wineries exhibited at the 2005 Vinexpo, a bi-annual tradeshow in Bordeaux. Thus, the benefit of using matching algorithms to pre-qualify potential pairings has some appeal. We have devised algorithms based on database filtering techniques and Operations Research methodology, with the theoretical underpinnings shown in greater

detail in Appendix A. These algorithms will allow for the optimal matches to be found, no matter how large the participant base grows.

1.1.2. Summary of Results

A review of the results from the initial matching shows that Global Match has potential benefits to offer participants, but that it is also in need of additional development. More distributors need to be recruited, a fact that can be seen from examining the initial requests. Over 274,000 cases of wine were available for allocation by wineries, but distributors' inquiries in aggregate totaled to a mere 124,000 cases. From the start it was obvious that over half of the wine would not be matched.

Of the 675 winery-distributor combinations possible, nearly 200 could be immediately removed from consideration on the basis of wineries not meeting distributors' needs with respect to pricing, varietals, or wine appellation. Once the wineries' needs were also considered the list could be paired down further to 150 potential relationships. Finally, when the matching program was run considering all constraints, 31 distinct winery-distributor pairings were recommended. These matches would enable 60 different products to be moved, as some distributors were matched with multiple products from a winery. The aggregate volume allocated from these matches totaled just over 50,000 cases.

One can also examine the results as to how well the matches provided wineries the geographic placement they desired. The average geographical attractiveness of all the original 150 possible matches where some degree of mutual fit occurred was 0.3. This average score is relatively low, give than a distributor's attractiveness can range from 0, if they have no states of interest to a winery, to 1, if they have licenses for all the states that the winery has interest in. Averaging the matching results shows that overall geographic placement improved to 0.38. When the attractiveness of a match was calculated as a weighted average also considering the volume of wine to be matched, this metric improved further, to 0.53.

It should be noted that the program's recommended matches are non-binding. Just as a dating service cannot arrange weddings for people they deem as eminently suited to each other, we had no authority to force a relationship. Wine is a complex product, and a distributor may reject a product that fits all the stated requirements because of taste or other hard-to-quantify factors, such as whether the personalities or cultures of the parties are mutually compatible. A service like Global Match provides the necessary, but not sufficient conditions for creating a partnership. Thus, program participants were provided not only with their recommended matches, but with a list of all possible matches in decreasing order of geographic fit, although these secondary recommendations were not checked for domain overlap.

1.1.3. Participant Feedback and a Success Story

We emailed the participants their recommended matches and additional potential partnerships, and solicited feedback on the program. Follow up communications revealed that at least one viable match resulted from the program. JanKris, a family winery based in Paso-Robles had the price point, varietals and appellation that Superior Brands, a Colorado-based distributor, was seeking. To quote Scott Curtis, the CEO of Superior Brands, "I actually did find JanKris through [Global Match]…. They are now one of our best selling brands in our book and we are even making our new private label blend with them." To quote Mark Geldon, the founder of JanKris, "Scott's company is now the second most productive distributor we have out of twenty three states. … If it was not for the matching program I don't believe we would have ever connected and created such a profitable relationship."

Although other participants did not mention specific relationships developed from the program, many were enthusiastic about participating in future matchmaking, and some even wished to forward information about the program to colleagues in other organizations to encourage them to join. This congenial networking between wineries and even non-competing distributors should help to expand the participant base for future program efforts.

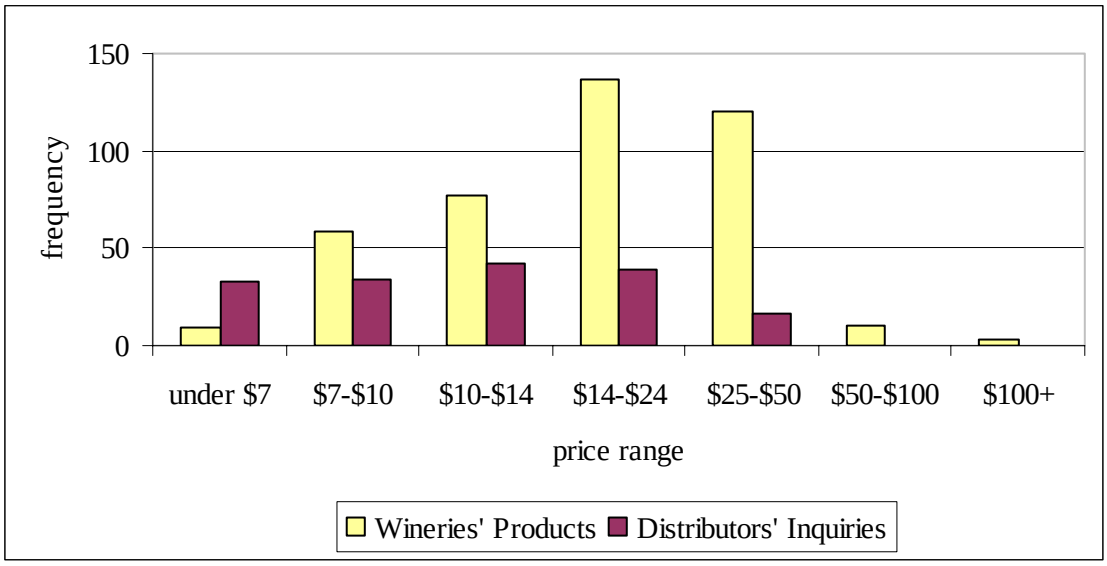
1.1.4. Further Analysis of Results

Although it would be easy to focus only on the successes and enthusiastic endorsements, we also examined the results to garner ideas for improvement. A valid question to ask is why wasn't the program more successful in matching? While the imbalance in participation between wineries and distributors prevented all the wineries' products from being matched, the matching still only allocated 40% of the total volume equivalent of all the distributors' inquiries.

Some of the wineries were likely to find less satisfactory matches because they sought markets not well represented by the set of participating distributors. One winery did not receive any matches in the program because their desired markets were not covered by any of the distributors. Likewise, one distributor received no recommendations because they had a license for only one state, New Hampshire, which none of the wineries listed as a target market. Some distributors covered states where many wineries already had representation, and the domain overlap restrictions prevented matches. We were initially concerned with whether the weight values (shown in Figure 4) would have great effect on the matches. However, extensive scenario analysis with different values for these weights showed only minor changes (Sheaves, 2005).

While some distributors desired very specific varietals or appellations, for the most part the variety of wines was sufficient to accommodate their requests (Sheaves, 2005). The lack of more matches can be explained by Figure 7, which compares the suggested retail price (SRP) of products offered by wineries to the price range that distributors were seeking per inquiry. If a distributor provided an inquiry that had a wide price range, multiple price segments were checked. As an example, if an inquiry requested a product that retailed for more than USD 10 but less than USD 40, this inquiry would count in all the following ranges: USD 10-14, USD 14-24 and USD 25-50. Volumes are not taken into account in this chart; whether a winery is offering 100 or 10,000 cases of USD 14 zinfandel is not tallied any differently.

Figure 7 What Participating Wineries Are Offering and What Distributors Are Seeking by Price Segment



Source: Data from original matching program, May 2004.

The graph shows a fundamental pricing mismatch between the wineries' offerings and the distributors' pricing needs. It would appear distributors hoped to find wines in the USD 7 and under category, an unrealistic price point for smaller producers, as they have to amortize the high fixed costs of running a winery. However, it is more likely that many of the entries in this category result from distributors not providing a lower price cutoff and specifying only an upper price limit. But it is clear that distributors' pricing requests in aggregate were lower than the wineries offered. A winery hoping to place wines over USD 50 would have had no matches

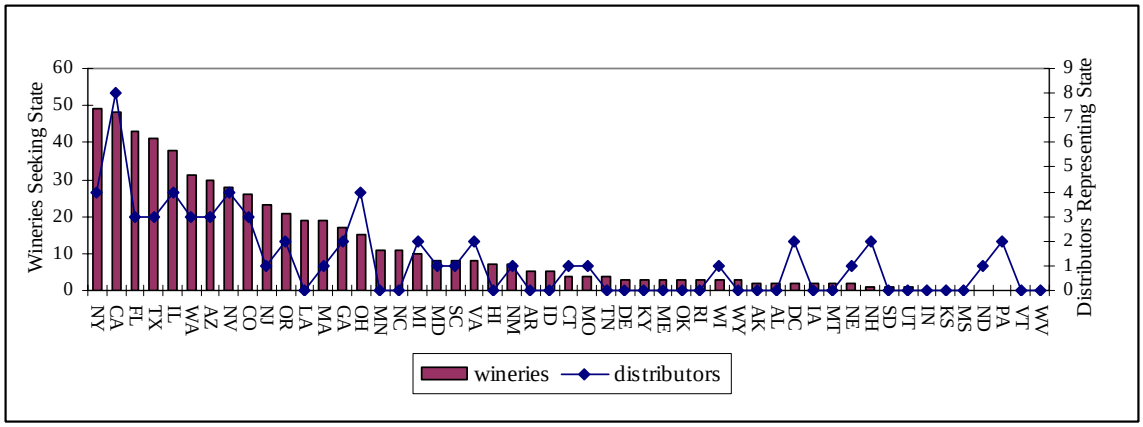
in this program, and those in the second most popular price segment, USD 25 to 50, faced a lot of competition for very little distributor interest.

While some wineries might request that more luxury-wine focused distributors should be recruited, other commentators might suggest that wineries should have more realistic expectations of what the market can bear and to not assume all specialty distributors seek expensive wines. Wineries planning to participate in the program could use this information to determine which wines they might expect to have greater chances of placement. Perhaps a strategy of establishing distributor relationships through initial sales of lower priced blends than of reserve cabernet sauvignons would be appropriate. A winery that can bring a wider price range of products to the matching will likely have more success that one that offers only USD 35 varietals. This analysis can be done with other attributes than price. Successive iterations of the matching program might even be used to document and predict shifting market tastes in varietals or for certain appellations.

2. Planned Improvements and Future Research

Many improvements are planned for the next version of Global Match. The results from the first iteration suggest how to focus recruiting efforts for the program. The most obvious point is that in order to serve wineries better, additional distributors need to be actively recruited. But this quest for expanding the distributor base can be more finely honed after examining the results. Figure 8 tallies both wineries' interests by state and the number of distributors representing that state. Clearly, it would be ineffective to recruit distributors from New Hampshire, which is already represented and has received no interest from wineries. New York and California are both highly desired, but twice as many participating distributors represent the latter state than the former state. New York distributors are less likely to travel to a trade show based in San Francisco than those already instate, and one advantage an internet-based matching program provides is the lack of inherent geographic bias in participation resulting from the barriers of travel costs and time.

Figure 8 States Desired by Wineries and Represented by Distributors, as Sorted by Decreasing Frequency of Wineries' Preferences



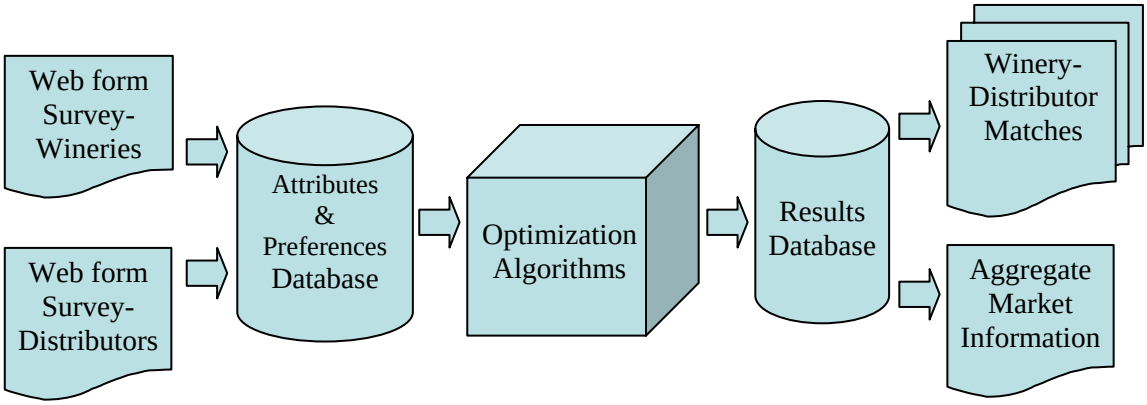
Source: Data from original matching program, May 2004.

Although the initial emphasis was on finding U.S. distribution for wineries, the next iteration will target additional participation from export brokers, importers and foreign buyers. Once again, the use of the internet removes travel barriers. Wineries should be able to leverage the category-building efforts of trade organizations to promote Californian wine, and we are partnering with the Wine Institute to use Global Match as part of their export-focused activities.

In order to allow for such global participation, the program needs to be implemented to support web-based data entry and maintain a degree of privacy. Efforts are currently underway to design an interface where participants can log in, add or update their information and view their specific matching results, as well as aggregate market information. Wineries shopping

around for better representation may choose to mask their identity, in case they fear encountering their current distributor online. Aggregate information will be displayed on the programs' website. Figure 9 displays this information schema.

Figure 9 Information Schema for Global Match



Source: Author's contribution.

This research is focused on assisting U.S. wineries as it is currently funded by the U.S. Department of Education. We aim to expand the program in the future to include producers from other countries. Thus, the program is being implemented to be able to accommodate the differences in how countries categorize their wines. For instance, Californian producers sell mostly single-varietal wines, but French winemakers tend to produce appellation-specified blends. The program uses data-driven tables, so it will be easy to change regions, varietals/blends and other country-specific features. Distributors would be able to seek wines from all participating countries. This broader reach would increase the value of the matching program for distributors, as it would provide them with more wines to evaluate. The increased appeal of the program should result in greater participation by distributors and thus benefit all wineries. The cynic may argue that helping the small producer in France or Italy find distribution cuts into the market share of the small Californian producer. But we feel that the true competition for distributors' attention, retailers' shelf space and restaurants' wine lists, and, ultimately, end consumption are the wines from the large producers.

3. Conclusion

In this era of globalization and consolidation, small wineries face difficulty in obtaining the attention and shelf space of the large distributors and retailers. While a market does exist for these products, it may be difficult for wineries to find the appropriate specialty distributors. To assist in this search we have created Global Match, a free program enabling participants to pre-qualify potential partnerships through registration at a virtual, web-based trade show. Through analysis of the program's results, we plan to make further improvements and better target potential participants.

Ultimately we hope to expand the program to consider wineries from other countries. Small producers in Mendocino, California, Montefalco, Italy and Minerve, France all face similar barriers in reaching the end consumer world wide. Their competition is not so much with each other but rather the large wine producers, whether these goliaths are American, French, or, increasingly, multinational conglomerates of brands from over the world. Global Match is one tool that can help expand the effective reach of the small winery. Ultimately this will benefit the end consumer as well, as they will continue to be able to purchase a wide selection of small, independent producers' wines.

4. Appendix A: Formulation of Global Match

The problem is formulated as a mixed integer program (MIP) that borrows from the tradition of both classic assignment and maximal flow problem models. The model maximizes the weighted volume of wine traded over preferred markets, subject to qualification based on

mutual fit and the constraints of supply, demand and avoidance of domain overlap. A literature search reveals that this application is the first such mathematical model to attempt to optimize assignment of wineries to distributors. Given this MIP formulation, the solution is guaranteed to be globally optimal; no better solution can be found that will better allocate the wine and still satisfy all given constraints. This listing of the model's specifications can be found in Cholette (2006), along with additional technical details.

Indices

W =	$\{w\}$	set of wineries
P =	$\{p\}$	set of a winery's products (wine), up to 6 products allowed per winery
D =	$\{d\}$	set of distributors
Q =	$\{q\}$	set of a distributor's inquiries, up to 6 inquiries allowed per distributor
S =	$\{s\}$	set of markets, defined as the 50 U.S. states and the District of Columbia

Data Parameters: Volumes are measured in cases, where 1 case = 12 750ml bottles

$$L_{d,s} = \begin{cases} 1 \text{ if distributor } d \text{ has license to distribute in market } s \\ 0 \text{ otherwise} \end{cases}$$

$$E_{w,s} = \begin{cases} 1 \text{ if winery } w \text{ already has distributor representation in market } s \\ 0 \text{ otherwise} \end{cases}$$

$R_{w,s}$ cardinal preference of a winery w for market s, as determined by Table 2
$S_{w,p}$ supply (cases) of product p by winery w
$D_{d,q}$ demand (cases) for inquiry q by distributor d
$M_{w,d}$ upper limit of cases that could be allocated from winery w to distributor d

Variables

$v_{w,p.d,q}$ volume (cases) of winery w's product p allocated to meet distributor d's inquiry q

$$m_{w,d} = \begin{cases} 1 \text{ if any product from winery } w \text{ is allocated to distributor } d \\ 0 \text{ otherwise} \end{cases}$$

Pre-solve Calculations

Upper Limit Check: Product p from winery w will be eligible to meet distributor d's inquiry q if it satisfies the distributor's desired varietal and appellation, falls within the accepted price range and geographic overlap between winery's w desired markets and d's domain of distribution exists. The upper limit for this decision variable will be set to the minimum of the winery's available supply and the distributor's demand.

$$\overline{v}_{w,p,d,q} = \begin{cases} \min(S_{w,p}, D_{d,q}) \text{ if allocation is possible} \\ 0 \text{ otherwise} \end{cases}$$

Distributor Overlap with Other Distributors: This is a lower triangular **D** x **D** matrix indicating where 2 distributors' domains overlap.

$$DO_{d1,d2} \geq \sum_{s \in \mathbf{S}} L_{d1,s} L_{d2,s} \qquad \forall d1, d2 \in \mathbf{D} \mid d1 > d2$$

Winery's Existing Overlap with Distributors: This is a **W** x **D** matrix indicating where distributors' domains overlap with each winery's current distribution.

$$EO_{w,d} \geq \sum_{s \in \mathbf{S}} E_{w,s} L_{d,s} \qquad \forall w \in \mathbf{W}, d \in \mathbf{D}$$

Objective Function: Maximize the weighted volume of all wine matched, weighted by the geographical attractiveness of a distributor for a winery:

$$Max \sum_{w \in \mathbf{W}} \sum_{d \in \mathbf{D}} g_{w,d} \sum_{p \in \mathbf{P}} \sum_{q \in \mathbf{Q}} v_{w,p,d,q}$$

$$\text{where } g_{w,d} = \sum_{s \in \mathbf{S}} R_{w,s} L_{d,s} \quad \forall w \in \mathbf{W}, d \in \mathbf{D}$$

Optimization Constraints

Supply of Wineries' Products Available: The summation of cases of a winery's product allocated over all distributors must not exceed the winery's availability for that product:

$$S_{w,p} \geq \sum_{d \in \mathbf{D}} \sum_{q \in \mathbf{Q}} v_{w,p,d,q} \qquad \forall w \in \mathbf{W}, p \in \mathbf{P}$$

Demand Cap for Distributors' Inquiries: The summation of cases of products allocated from all wineries to satisfy a distributor's inquiry must not exceed what the distributor has requested:

$$D_{d,q} \geq \sum_{w \in \mathbf{W}} \sum_{p \in \mathbf{P}} v_{w,p,d,q} \qquad \forall d \in \mathbf{D}, q \in \mathbf{Q}$$

Match Acknowledgement: A match between a winery and a distributor exists if any of that winery's products are allocated to meet any of the distributor's inquiries:

$$M_{w,d} m_{w,d} \geq \sum_{p \in \mathbf{P}} \sum_{q \in \mathbf{Q}} v_{w,p,d,q} \qquad \forall w \in \mathbf{W}, d \in \mathbf{D}$$

Distributor Assignment Overlap Prevention: If distributors' domains overlap, at most one match is made for any one winery:

$$m_{w,d1} + m_{w,d2} \leq 1 \qquad \forall w \in \mathbf{W},\ d1,d2 \in \mathbf{D} \mid DO_{d1,d2} > 0$$

Prior Relationship Overlap Protection: No wines can be allocated that would result in domain overlap, given the pre-existing relationships that wineries have with distributors:

$$0 \geq \sum_{p \in \mathbf{P}} \sum_{q \in \mathbf{Q}} v_{w,p,d,q} \qquad \forall w \in \mathbf{W}, d \in \mathbf{D} \mid EO_{w,d} > 0$$

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